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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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PAPER MILL LUBRICATION

PAPER has become such a commonplace commodity in our lives that one seldom stops to consider its romantic origin, the numerous ways that it serves our needs, or the gradual development of paper making into one of the world's leading industries.

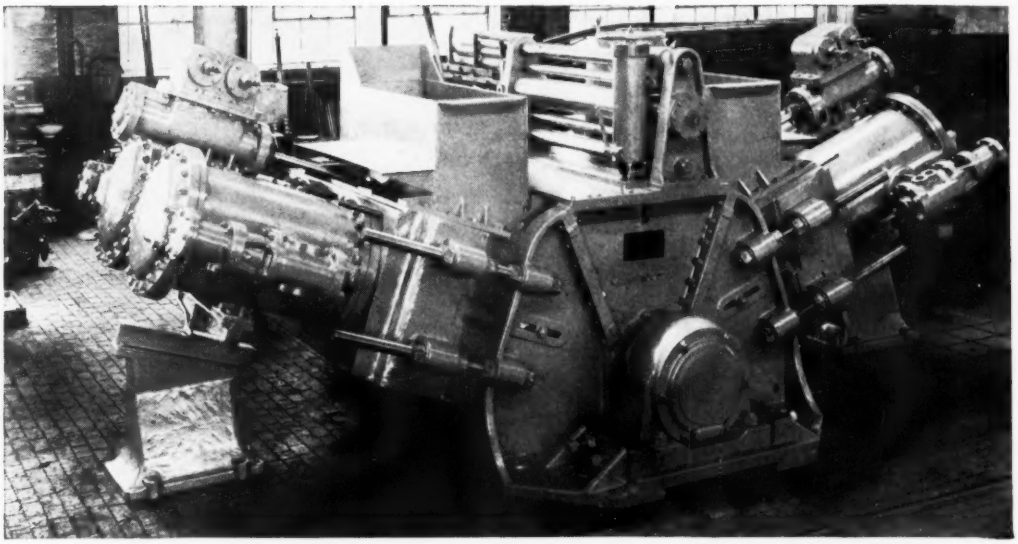
While it may be debatable as to who made the first paper as we know it today, the invention is generally credited to the Chinese, and especially to one Ts'ai Lun, approximately two thousand years ago. Ts'ai Lun's paper and his method of preparation were primitive duplicates of our present day products and operations, being made from a water slurry of wood fibers which was allowed to air dry over a woven meshed fabric. Paper making was a Chinese secret for over half a century before it was discovered by the Arabs who were responsible for its introduction into Western civilization.

One has only to consider the laborious efforts of primitive man in attempting to preserve his thinking and beliefs for posterity by chiseling symbols in stone surfaces, and subsequent writings of a similar nature, to appreciate the inestimable debt which modern civilization owes to all those who contributed their efforts in the development of paper making as carried out today. If paper had not been available to our early scholars on which to record their philosophies and scientific findings these could only have been preserved by word of mouth to selected disciples and would have been lost or greatly distorted in a short time. The advancements made in the paper industry, both as regards quantity and quality, have extended the use of paper to numerous applications other than printing. Bags, paperboard and tissue are the principal secondary outlets for paper products. The paper industry owes considerable of its present industrial position to these products.

Manufacture of paper is essentially a chemical process in which crude cellulose materials are chemically treated to remove undesirable constituents, admixed with other chemicals which impart desired characteristics and finally felted from dilute water slurries and dried to form the paper. There are a large number of natural sources of cellulose which have been used for paper manufacture but wood is the only one of major significance in today's operation. The greater percentage of our paper is made from soft wood such as spruce and pine but a sizeable percentage is obtained from hardwood. There are three basic chemical processes in the Paper Industry, namely "Sulfite", Sulphate" and "Soda" processes.

In spite of the fact that paper making is chemical in nature, it is dependent upon mechanical equipment at each step in the processing to insure continuous production of a uniform product. Fortunately, this equipment is largely independent of the raw material used and the method of processing.

This greatly simplifies the problem for the lubrication engineer who has the responsibility of keeping all the equipment operating with minimum shutdowns and waste, both of which would be reflected in the overall lubrication costs. A description



Courtesy of Montague Machine Company

Figure 1 — Great Northern Grinder for Four Foot Wood.

of the lubrication practices employed in all the process and auxiliary equipment of a paper mill is beyond the scope of this article, consequently the lubrication of motors, fans, pumps, etc., should be reviewed in other articles devoted specifically to these individual units.

The highlights of the lubrication of the process equipment normal to most paper mills are presented in the order of stock development.

WOOD YARD

Wood for paper manufacture is usually cut to the desired log length in the woods and delivered to the mills by rail, truck, or water. After arriving at the paper mill the raw material is moved from one operation to the next by means of conveyors until the wood chips are deposited in the chip storage bins at the top of the digesters. The conveyors are driven by sprocket wheels and chains motivated by electric motors through suitable reduction gears. Lubricants are usually applied by hand although wick feed cups are applicable. When the latter are used the oils must be more carefully selected as the ability to flow is very important. In cold weather it is essential to use a low pour point oil. The driving gears and sprockets require a sufficiently heavy adhesive lubricant to insure that it will remain on the parts being lubricated. Where grease cups or pressure fittings are provided, water resistant calcium soap greases should be used.

BARKERS

The first step in the preparation of the wood for paper manufacture is the debarking operation which removes the bark from the logs. This is essential as bark does not respond to the subsequent chemical treatments and the presence of even small quantities will result in discoloration of the final sheet due to bark specks. There are two distinct debarking procedures currently employed; the selection of which is primarily dependent upon the size of the wood being processed. The first method, used for large diameter logs, consists of sawing the logs lengthwise into "cants" having average cross sections of four by twelve inches. These "cants" are then put singly through barking machines in which high speed and adjustable rotating curved knives strip off the bark.

The second and most commonly used debarking method consists of tumbling four-foot log sections in large horizontal open end cylinders. These Barking Drums are fabricated from channel irons and vary in size, the larger ones being approximately twelve feet in diameter and forty-five feet long. The drums are mounted at a slight angle and operate continuously with the wood being fed into the higher end and discharging from the lower end.

There are two general methods of mounting these drums and each calls for a different type of driving mechanism with variation in lubrication requirements. In some cases the drums are placed on multiple trunnion mountings and are electrically driven through exposed reducing gears to a large girth gear. The open gears are satisfactorily hand lubricated with heavy gear oils designed to have sufficient adhesiveness to insure their staying on the gear surfaces, and mild extreme pressure characteristics to reduce wear. Modern trunnion bearings

are of the double roller self-aligning type designed to withstand the high loads and rough usage to which gears in this service are subjected. These are generally grease lubricated and a relatively soft, water resistant calcium soap grease is recommended due to the continual exposure of the bearings to water and unfavorable weather conditions.

An alternate method of barking drum installation involves suspending it from an overhead frame by means of heavy chains. The drum is driven by means of a motor, located on top of the frame, through a suitable open gear reduction to a chain which encircles the drum on a sprocket. In this type of driving mechanism the chain drives and open gears as well as the plain bearings of the reduction wheels and drum guides should be lubricated with the same types of products as recommended for the trunnion mounted drum.

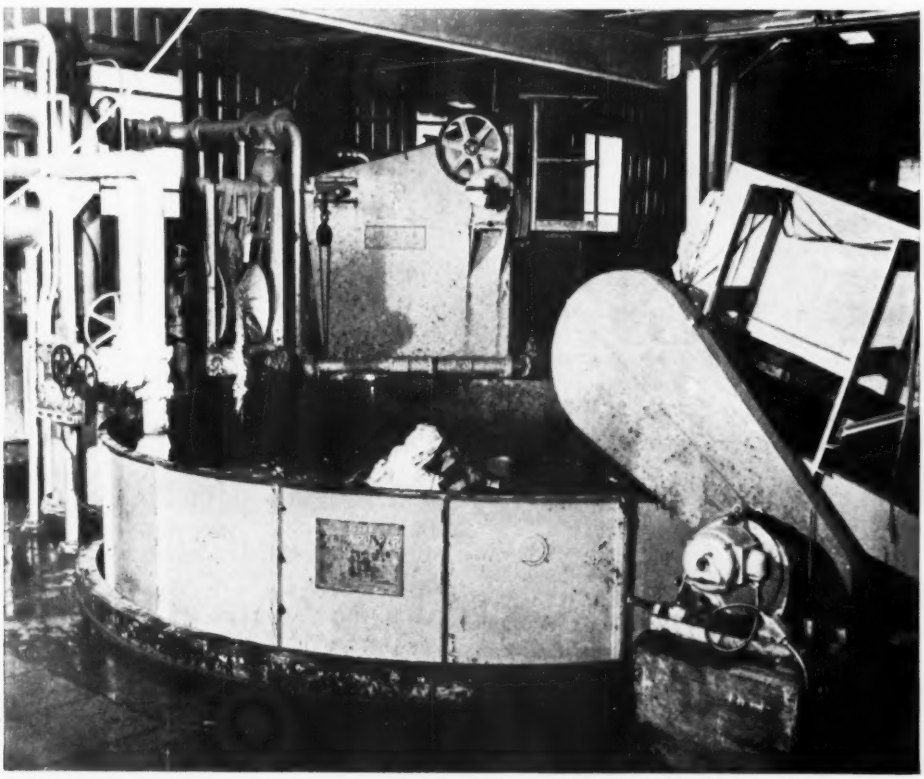
The logs discharging from the barking drums are carefully inspected and those containing more than a small amount of bark are recycled through the drum. The clean logs are conveyed to either a grinder or chipper, for reduction to the proper size for subsequent processing, depending on the type of paper being manufactured.

GRINDERS

A large percentage of the paper which is used today is required to give very limited service before it is destroyed, consequently it does not have to be of very high quality. The best example of this is newsprint. These papers contain high percentages of groundwood pulp which is obtained by running logs under pressure against a revolving stone. This groundwood receives no subsequent chemical treatment but is normally mixed with varying percentages of chemical pulps to impart desired properties to the resulting paper.

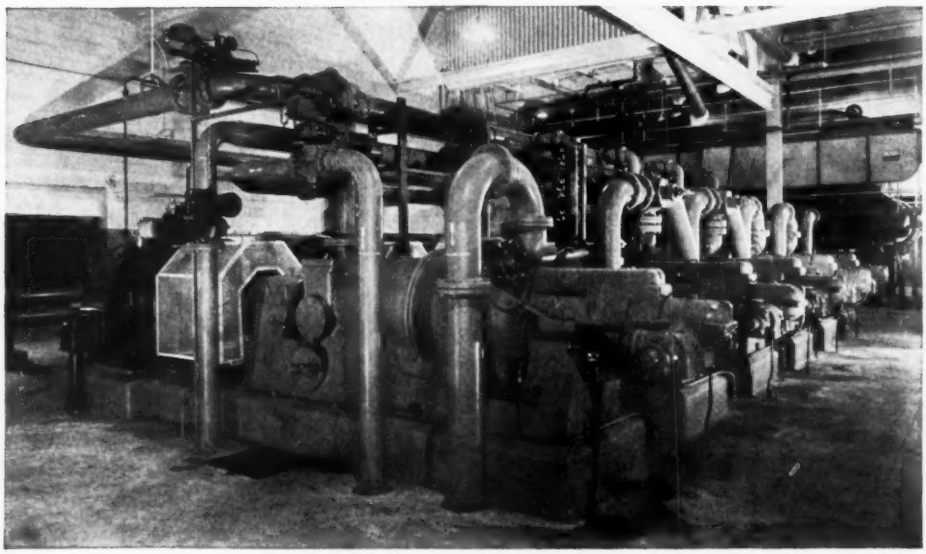
Advances made in the preparation of groundwood pulp together with the increased use of this stock in a wide variety of papers constitute a major change in current paper making.

The logs from the barking drums are charged to the grinders which vary considerably in design but all work on the same general principle. These units consist essentially of a grinding wheel having diameters from 54 to 62 inches and widths sufficient to accommodate four-foot logs. The stone is mounted vertically on a large shaft and revolves within a steel housing having from two to four "pockets" each of which holds several logs which



Courtesy of Shartle Bros. Machine Company Division of Black-Clawson Company

Figure 2 — Shartle Continuous Hydrapulper.



Courtesy of Shartle Bros. Machine Company Division of Black-Clawson Company

Figure 3 — Battery of Six Shartle — Miami No. 2-A Jordans.

are forced against the grinding stone by hydraulically driven piston heads in the top of the pockets. Artificial grindstones made of silicon carbide and similar abrasives are replacing natural stones due to their greater uniformity. The developments in grinder design have been directed toward greater production and has resulted in semi-automatic magazine type grinders and finally continuous grinders. The grinding operation is carried out under a full stream of water for the twofold purpose of reducing the temperature and cleaning the grinding surface of the stone.

The grinders in use today vary greatly in size and capacity and their design provides for different types of bearing lubrication. The earlier machines usually were provided with ring-oiled bearings and were lubricated satisfactorily with straight mineral oils. Some older machines had bearings equipped with recessed cups requiring the use of greases or oiled waste. As grinders have been increased in size there has been a tendency toward oil lubricated anti-friction roller bearings. The lubrication of grinder bearings, especially the roller bearings, frequently presents a problem due to water and/or pulp being forced through the packing and into the housings. This not only impairs lubrication but may result in bearing corrosion. This difficulty can be minimized by resorting to the use of higher viscosity lubricants. In the case of roller bearings which are subjected to greater pressures, wear and corrosion due to a slight water leakage can be eliminated by the use of oils having mild extreme pressure characteristics and a small degree of water sensitivity.

CHIPPERS

When cleaned logs from the barking drums are to be used for the manufacture of chemical pulp, they are reduced to processing size in a "chipper" instead of a "grinder". The chipper is of a simple but very rugged construction. It consists of a round solid iron disc having a diameter as large as nine feet and a normal thickness of four inches with from four to twelve sets of knives placed radially on one of its surfaces. The disc is mounted vertically on a shaft supported by bearings on either end. The logs are fed lengthwise through a spout inclined at an angle of forty-five degrees to the disc. The ability of a "chipper" to cut a seven-eighths inch slice across an eight-inch log is due to the high centrifugal force of the disc which weighs three tons and revolves at a rate of 300-600 RPM.

As in most other units of paper making equipment roller bearings have replaced plain bearings. These are usually grease lubricated. A No. 2 consistency heavy duty grease is recommended for this service due to the shock vibration set up by the cutting action.

The chips produced are classified on an oscillating screen and the oversized ones are sent to a rechipper for further reduction in size. Those of proper size are carried by conveyors to the chip storage bins on top of the digesters. After chemical treatment in the digesters and subsequent removal of chemicals in the blow-pits the pulp is next subjected to a series of screening operations for the removal of fiber clusters, knots and slivers.

PULP SCREENS

The screens used in pulp refining may be of the flat, rotary or centrifugal types. Older equipment currently in use has plain or sleeve type bearings which can be lubricated by oils fed through wicks or by grease fed through compression fittings. The lubrication requirements of these screens are not too exacting but care must be taken to insure against the detrimental effects of water. Straight mineral oils of 300-500 second viscosity are generally satisfactory on the wick fed bearings while a water resistant grease of No. 3 consistency is recommended where grease fittings are provided.

The newer type screens are almost exclusively designed to include anti-friction type bearings with pressure fittings for grease lubrication. The same type of grease is used on these bearings as in those provided with compression cups.

DECKERS AND WET PULP MACHINES

After leaving the screens the pulp is passed through deckers to remove a part of the water from the stock. The decker consists of a cylinder which revolves in a vat and carries the wet pulp to the top, where it is lifted from the surface of the cylinder by couch rolls. As the latter revolves a stationary blade removes the pulp which falls into a pocket and flows to the stock chest.

Due to the fact that water and the wet stock may be constantly splashed on the bearings it is frequently necessary to use a compounded oil in order to obtain satisfactory lubrication. Where water does not present a problem, a straight mineral oil of 300-500 second viscosity fed by wicks or bottle oilers is satisfactory. Where grease fittings or cups are provided, heavy water resistant greases should be used to insure against the damaging effects of water.

When pulp is being stored or shipped it is necessary to reduce its water content as far as possible, without resorting to heating, in order to facilitate handling and effect shipping economies. The wet pulp machine consisting of a series of press rolls accomplishes this objective. This machine usually is equipped with ball or roller bearings although some types will be found with sleeve bearings. The same recommendations are made for the lubrication of the wet pulp machine bearings as for those on the deckers.

BLEACHING

Wood pulp invariably contains small amounts of colored lignin products and must be bleached if it is to be used for the finer grades of light colored papers. Bleaching is a chemical process performed continuously in present practice as compared to the earlier batch procedure. Several bleaching procedures are used employing different chemicals and a multiplicity of equipment designs and methods of chemical application. With the exception of two transfer pumps, the pulp washer described below is the only item of interest from a lubrication standpoint. The bleached pulp must be thoroughly washed to free it of chemicals before further processing. This is normally accomplished on continuous rotary washers consisting of a large partly submerged perforated drum which revolves slowly in a tank of the pulp. Vacuum within the drum carries the pulp to the top where it is continuously spray washed to remove the chemicals. It is then removed from the cylinder.

The rotary pulp filter and washer gears and trunnion bearings are lubricated by means of an oil bath or sight feed cup. A heavy cylinder oil is recommended for this service since the bearings and gears are always subjected to appreciable amounts of water. The discharge roll bearings are usually furnished with pressure grease fittings and a No. 2 consistency grease is recommended for use on these bearings.

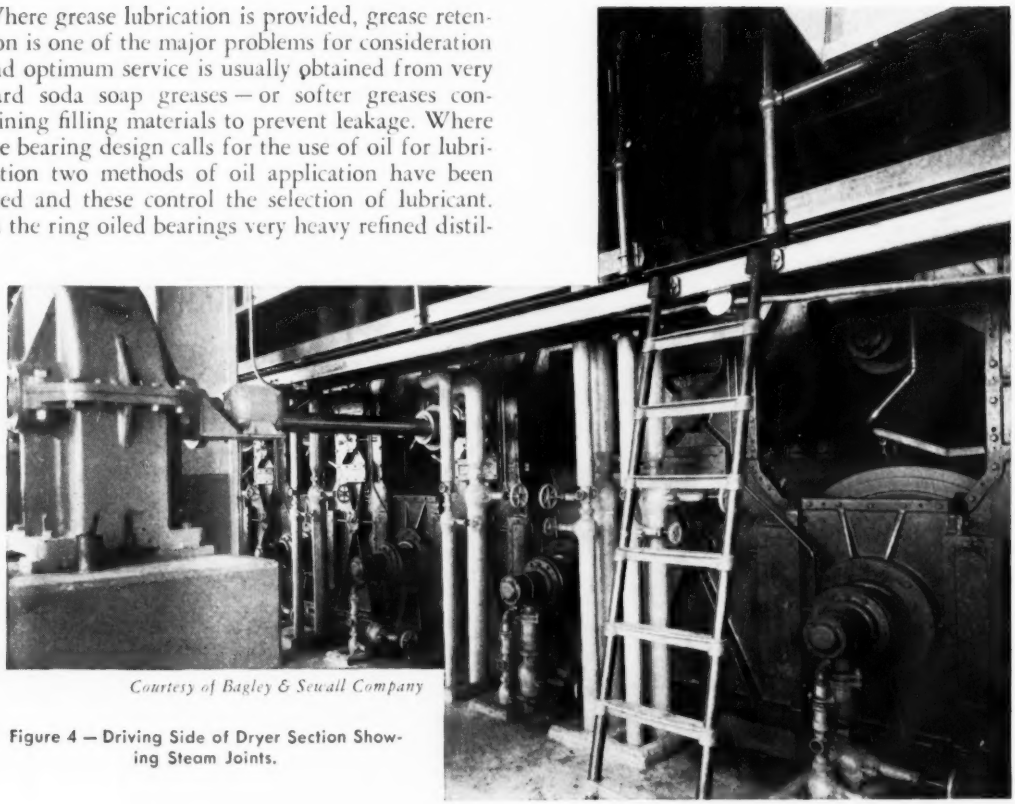
BEATERS

Up to the present time we have confined ourselves to the lubrication of equipment used in the manufacture of pulp as differentiated from paper. The manufacture of paper starts in the beater room. Beaters were invented in Holland over two hundred years ago and are often called "Hollanders". It is here that the paper ingredients, pulp, groundwood, coloring, size and filler are added, in accordance to a definite formula for the paper being made, and mixed by circulation under the beater roll.

The beater, or Hollander, consists of an open top wood or steel rectangular tank 25′ x 11′ x 3½′ with semicircular ends and containing a longitudinal center partition ("midfeather") which forms a circular trough of the tank. The beater roll is mounted directly over a bed-plate on one side of the tank. The entire circumferencial face of the beater roll as well as the bed-plate are made up of a large number of knives. As the roll revolves over the bed-plate a tearing and cutting of the pulp fibers takes place and this constitutes the first step in pulp refining. Fine adjustments between the two sets of knives control the degree of refining occurring in the beaters.

The beater rolls weigh several tons, operate at approximately 100 RPM and are supported on heavy journals which are frequently exposed to water or pulp. These conditions require that a careful study be made before recommending lubricants for this service. The units currently in use vary considerably in age and consequently are provided with different lubrication systems requiring either grease or oil.

Where grease lubrication is provided, grease retention is one of the major problems for consideration and optimum service is usually obtained from very hard soda soap greases — or softer greases containing filling materials to prevent leakage. Where the bearing design calls for the use of oil for lubrication two methods of oil application have been used and these control the selection of lubricant. In the ring oiled bearings very heavy refined distil-



Courtesy of Bagley & Sewall Company

Figure 4 — Driving Side of Dryer Section Showing Steam Joints.

late oils or even cylinder oils are recommended. Where oil is applied to the bearings by means of wick feeds the viscosity should be as high as possible commensurate with insuring a satisfactory flow of oil to the bearings.

The newer designs of tub beaters incorporate the use of anti-friction bearings on the beater rolls. These are the self-aligning type roller bearings which have replaced the plain or sleeve type bearings in most of the equipment used by the paper making industry. When used on tub beaters these bearings are normally lubricated through pressure grease fittings and a relatively soft grease is recommended.

While there are more of the "Hollander" type beaters in use than any other, there is a general trend in new mills to replace these with vertical vat type beaters. In these units, batches of stock are caused to rotate at moderately high speeds. Mixing and shearing actions result from impinging the stock against stationary vanes along the bottom side of the tank. These units are electrically driven from either the top or bottom through standard reduction gears containing a 600-700/100°F viscosity oil having mild extreme pressure characteristics.

JORDANS

The final refining of the stock before charging to the paper machine takes place in the Jordans. These machines consist of a conical plug which revolves at high speeds within a hollow cone or shell. The surface of the plug is fitted with longitudinal steel knives held in place by wooden fillers. A corresponding set of knives is set around the interior of the shell. As in the case of the drum beater roll, the clearance between the two sets of knives in the Jordan can be minutely adjusted by means of a handwheel and screw. The material is pumped into the small end of the cone and out the large end. In going through the Jordan, it is forced to pass through the very small space between the cone and the shell and between the whirling knives. It has often been said that, "Paper is made in the Jordans". It is normal practice to have a battery of three to six Jordans connected in series to insure the degree of refining desired. These are connected in such a manner that any of the units can be bypassed for repairs whenever necessary without stopping this phase of refining. It was the importance of the Jordan operations to the finished paper quality which led to early and continuous improvements in Jordan design and operations. Rope drives were replaced by belt drives which in turn gave way to direct motor connections. Plain bearings lubricated with block grease or oil soaked waste

were replaced with ring oiled or wick fed bearings. Self-aligning anti-friction roller bearings were placed on Jordans over fifteen years ago and are found on most units in use today. These are normally supplied with oil bath lubrication and regardless of sealing arrangements, oils with water separating and anti-rusting characteristics are recommended for this service.

The material from the Jordans goes to the stock chests where agitation holds the solid material in uniform suspension for charging to the paper machine. Consistency regulators control the consistency of the "stuff" fed to the machine to within very narrow tolerances which are necessary for the formation of a uniform sheet. All the operations up to this point have culminated in the formation of "stuff" which contains approximately 1.0% solids and 99.0% water. The process of paper making is now at the midway point; and the subsequent operations on the paper machine are directed toward the elimination of water, so that the final sheet will contain approximately 93% solids and 7% water. Dehydration is not the only objective in the final operations as it is also necessary that the machine operations result in a paper having required weight, strength, and surface characteristics.

PAPER MACHINES

There are two general classes of paper machines based on the methods of sheet formation. These are the "Fourdrinier" machine invented in France in 1799 and the "Cylinder" machine invented in this country in 1809. The former unit was not put into commercial practice in the United States until 1836. At the present time, practically all of our paper is manufactured on Fourdrinier machines. Except for a brief description of the "Cylinder" process, no mention will be made of this system.

CYLINDER MACHINE

The Cylinder machine forms the sheet on a wire cloth-covered cylinder which revolves in a vat of paper stock. The solids are held to the wire cloth by vacuum inside of the drum. The sheet is picked up on top of the cylinder by a long wet felt and carried to suction rolls, a series of squeeze rolls, a couple of press rolls and finally through a series of dryers.

The Cylinder machine has considerably more flexibility than the Fourdrinier since it can be used for the manufacture of any products having thicknesses ranging from tissue to half-inch wall board. In the case of the heavier products, it is necessary to use as many as six cylinders in series in order to obtain the desired thickness. In this type of operation, the felt picks up the web formed on each cylinder and they are compressed while in the wet state. Cylinder machines are used almost exclusively in the manufacture of building board, wall board, box board and roofing paper.

FOURDRINIER MACHINE

In any paper mill, it is the paper machine that is considered the "heart" of the operation and for which the numerous other pieces of equipment serve as auxiliaries. The economy of the entire plant is dependent upon the paper machine running practically continuously, except for scheduled shutdowns, and turning out paper to its maximum capacity. The greatly increased demands for paper and paper products have had definite effects upon the operation of existing paper machines (some of which are fifty years old) and the design of new machines. All changes have been directed at keeping the machines running longer and at greater speeds to satisfy the demand for more paper. The more important of these items are:

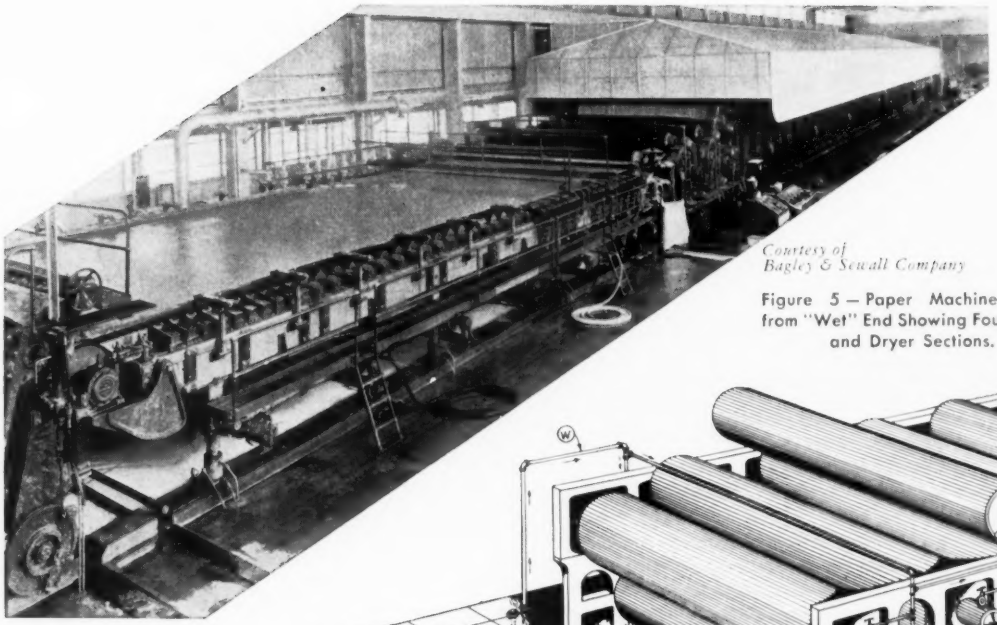
1. Use of self-aligning double-roller bearings on all rolls.
2. Use of higher steam pressures (up to 125 P.S.I.) to increase the drying rate. This necessitated use of
3. Improved oils having sufficient load carrying capacity at the higher temperatures to insure bearing protection.
4. Construction of wider machines, up to 300 inches.
5. Movable Fourdrinier sections on which wires can be changed in one-third the time as on stationary-type Fourdrinier.

The only way to really appreciate the tremendous improvements made in paper machines during the past fifty years is to compare the newest and oldest machines in some of our mills today.

In considering the operation and lubrication of a Fourdrinier machine, it is customary to consider it as consisting of two distinct sections – the "wet end" and the "dry end." At the "wet end" dehydration results from filtration by the wire, vacuum at the suction boxes, and pressure at the couch and press rolls. At this point in the operation, the solid content has increased from one to approximately thirty percent. The embryo paper leaving the press rolls enters the "dry end" of the machine where further dehydration is effected by evaporation caused by passing the sheet over a considerable number of large steam-heated rolls.

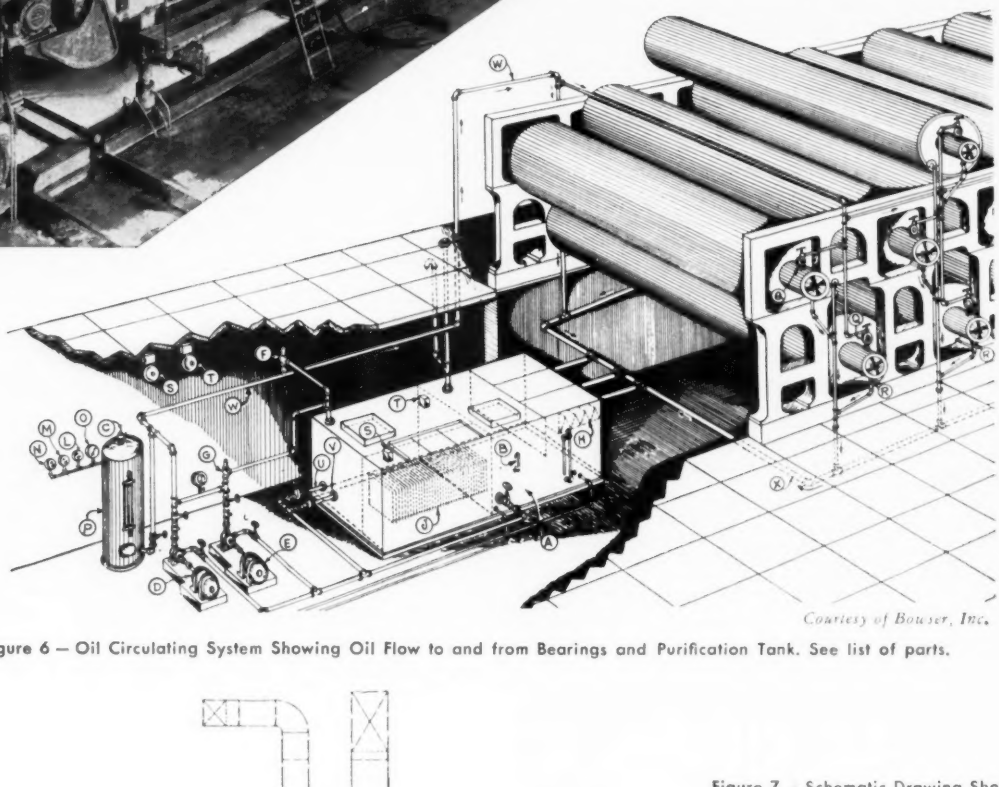
Wet End Operation

The "stuff" from the stock chest flows over an apron and onto the "wire" which is an endless belt



Courtesy of Bagley & Sewall Company

Figure 5 — Paper Machine — View from "Wet" End Showing Fourdrinier and Dryer Sections.



Courtesy of Bowser, Inc.

Figure 6 — Oil Circulating System Showing Oil Flow to and from Bearings and Purification Tank. See list of parts.

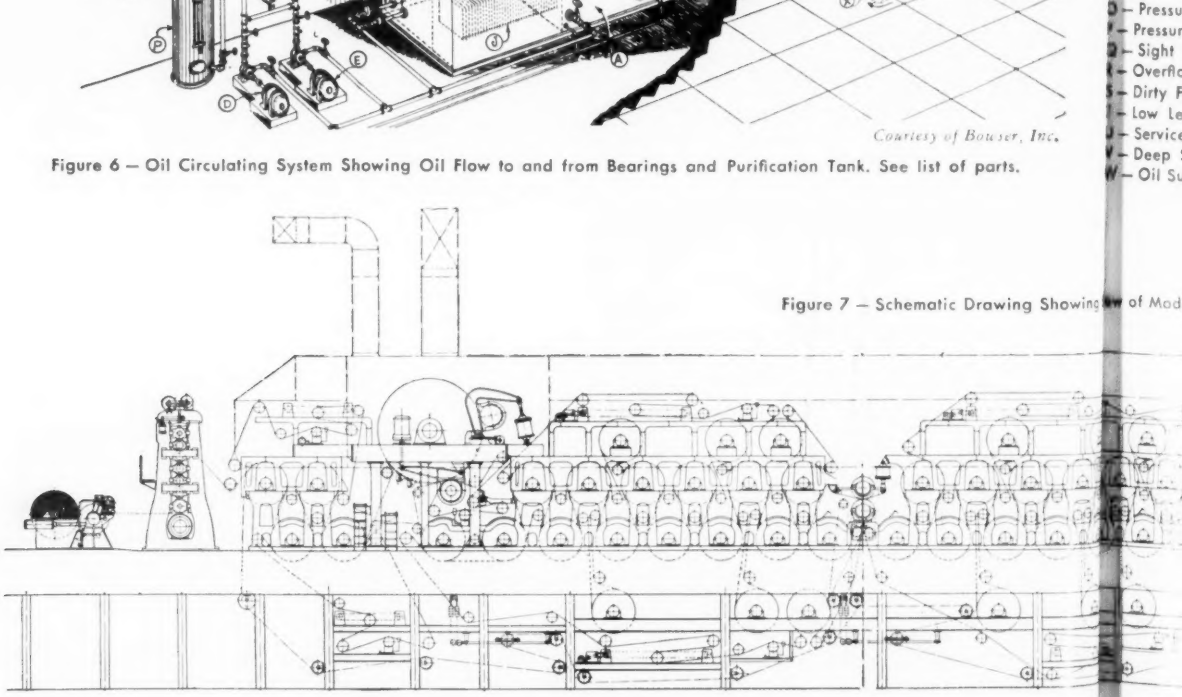


Figure 7 — Schematic Drawing Showing [illegible] **of Mod**

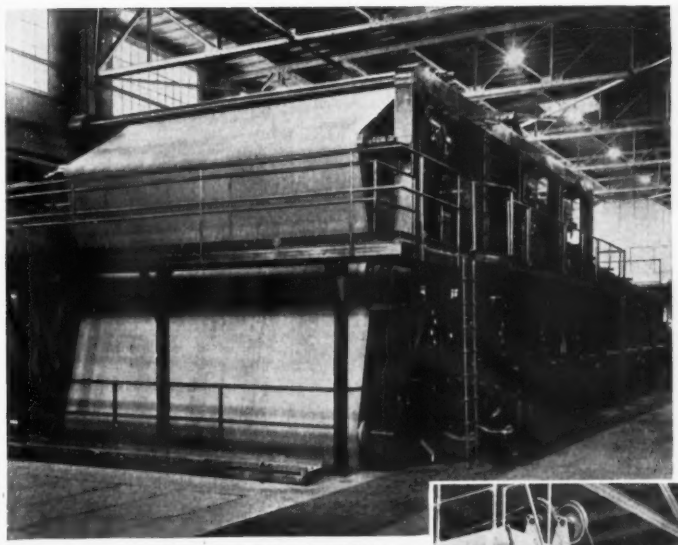
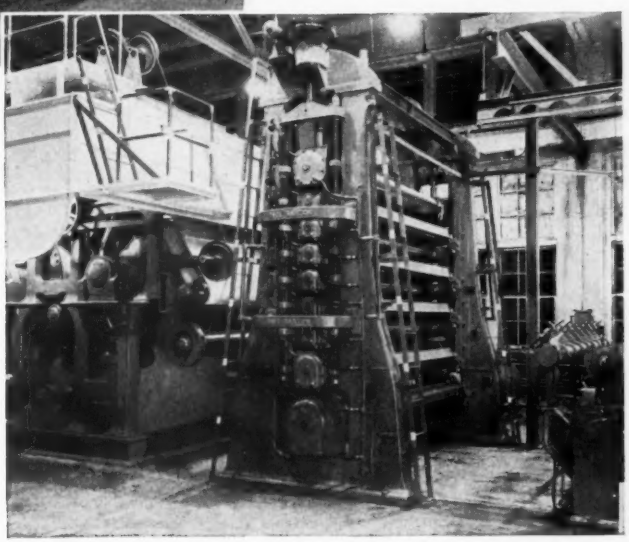


Figure 8 — Wet End of 216" Cylinder Machine.

Courtesy of Beloit Iron Works

Figure 9 — End View of Nine Roll Calendar Stack Illustrating Lubricating System.

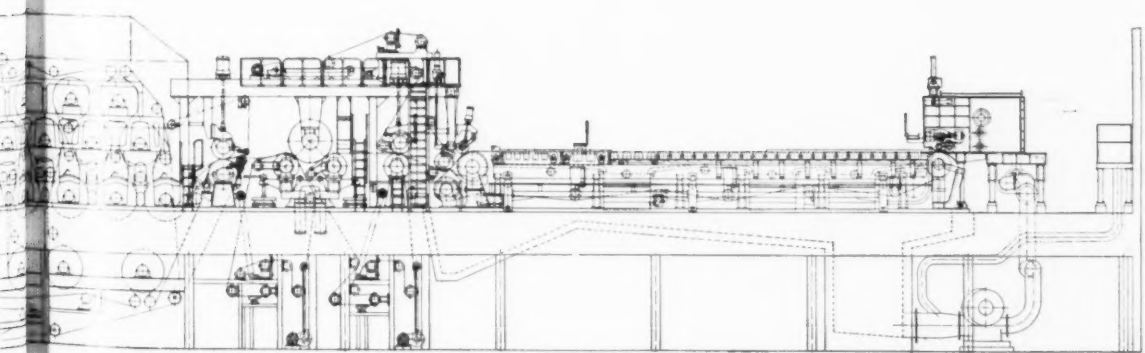


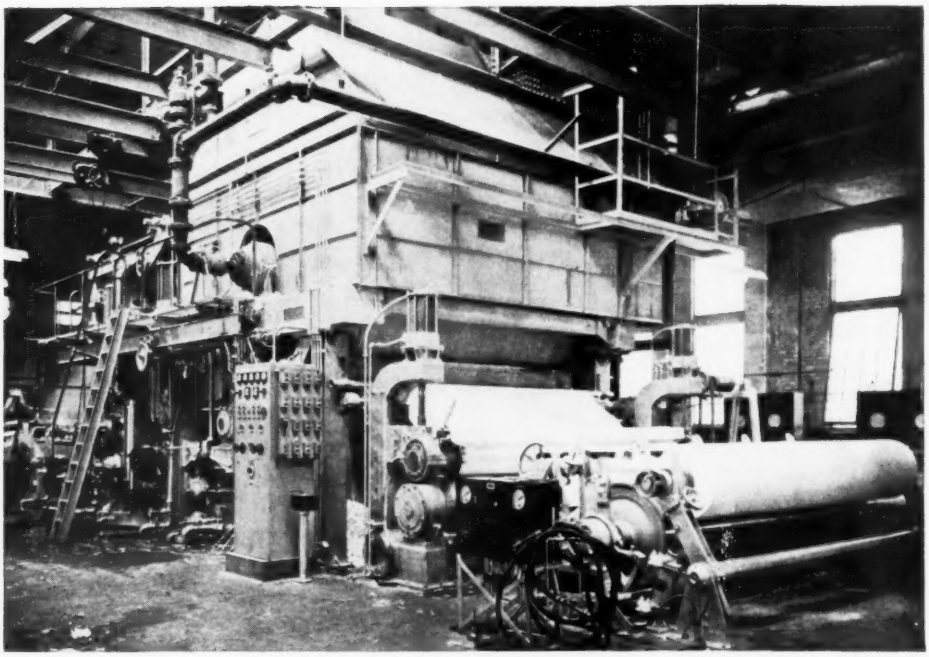
Courtesy of Rice Barton Corporation

— Receiving Tank and Filter.
— Thermometer.
— Safety Valve.
— Spare Pump.
— Service Pump.
— Relief Valve, System Protection.
— Relief Valve, Pump Protection.
— Screen Box.
— Filter Units.
— Pressure Switch, Spare Pump.
— Pressure Switch, Service Pump.
— Pressure Switch, Low P. Alarm.
— Pressure Gauge.
— Pressure Tank.
— Sight Feed Oilers.
— Overflows, (if required).
— Dirty Filter Alarm.
— Low Level Alarm.
— Service Suction.
— Deep Suction.
— Oil Supply Line.

ving w of Modern Fourdrinier Paper Machine.

Courtesy of The Pusey and Jones Company





Courtesy of The Pusey and Jones Company

Figure 10 — Typical Yankee Dryer Machine.

made of copper, bronze, or stainless steel screening. The "wire" travels at the speed set for the machine and is carried on a series of table rolls which maintain it in a single plane. The first roll in this series is appreciably larger than the balance and is driven by the wire. This is called the breast roll. In order to assist the water in passing through the wire and at the same time orient the cellulose fibers for the formation of a stronger sheet, the wire section is subjected to very definite vibratory action. After the wire has passed over the table rolls, it passes over suction boxes in which reduced pressure is maintained to promote further dehydration of the sheet. The water, which drains from the sheet, falls into a tiled tank, called a "saveall," from which it is pumped for reuse.

Located between the suction boxes is the dandy roll. This roll is of light weight construction and serves a two-fold purpose. It is used to smooth down the sheet while it still contains sufficient water to permit its being moulded. The dandy roll is also used to water mark the paper where this is desirable.

Couch and Press Rolls

After passing over the suction boxes, the wire with the web of paper passes between couch rolls where it is squeezed to remove more water. The rolls are normally two to three feet in diameter with the bottom roll being driven by an electric motor. The couch rolls drive the entire Fourdrinier section. Considerable pressure is placed upon the top roll by means of levers and weights.

Sufficient water is squeezed from the paper by the couch rolls so that the web will now support its own weight. At this point the wire is returned to the breast roll over return rolls located below the table rolls. On its return, it goes over a "stretch" roll which is adjustable and is used to maintain the correct tension on the wire. The web is passed on to an endless woolen felt which carries it through the press roll section which usually contains three sets of press rolls. The bottom rolls are made of iron and are covered with an inch of rubber. The top rolls are loaded either with lever arms and weights or by screws. Suction boxes similar to those below the wire in the Fourdrinier section are placed under the felt immediately in front of each set of press rolls. The press rolls reduce the moisture content of the paper to sixty five percent.

Wet End Lubrication

The operating conditions existing in the "wet end" are not so severe as to impose a challenge to the lubrication engineer. The temperature and bearing loading are comparatively low. The main points for consideration are the extremely wet conditions under which the bearings operate and the possibility of contamination with paper "stuff." These conditions caused considerable trouble in the earlier machines which were equipped with plain

or sleeve type bearings designed for oil or grease lubrication, due to inadequate sealing. In all new installations these bearings have been replaced by anti-friction bearings into which satisfactory sealing has been designed. With the possible exception of the table roll bearings which are of the ball bearing type the balance of the "wet end" rolls on double roller bearings. These are all equipped with pressure grease fittings and should be lubricated with a relatively soft water resistant grease.

Dry End Operation

The dryer section of a modern Fourdrinier machine consists of as many as one hundred steam heated dryer rolls which are five feet in diameter and twenty-five feet long. These rolls weigh approximately eighteen tons and are carried by heavy journals and double roller self-aligning bearings and operate at speeds as high as 150 RPM. The rolls are geared together at their journals in order to synchronize their running which is absolutely necessary. High pressure steam enters and leaves the dryer rolls through specially designed steam joints and the journal on the drive side of the unit. In addition to the paper dryers there are similar rolls for drying the felt and a greater number of small idler rolls over which the felt is threaded in the drying operation.

The paper web coming from the press rolls is transferred to the dryer felt which carries it through the dryer section. At this point the water content has been reduced to approximately seven percent. The final step consists of running the paper through one or more calender stacks depending upon the surface finish desired. The calender stack consists of seven or more steel rolls mounted vertically in a housing. The two bottom rolls and the top roll are larger than the intermediate ones. The whole stack is driven by friction on the bottom roll.

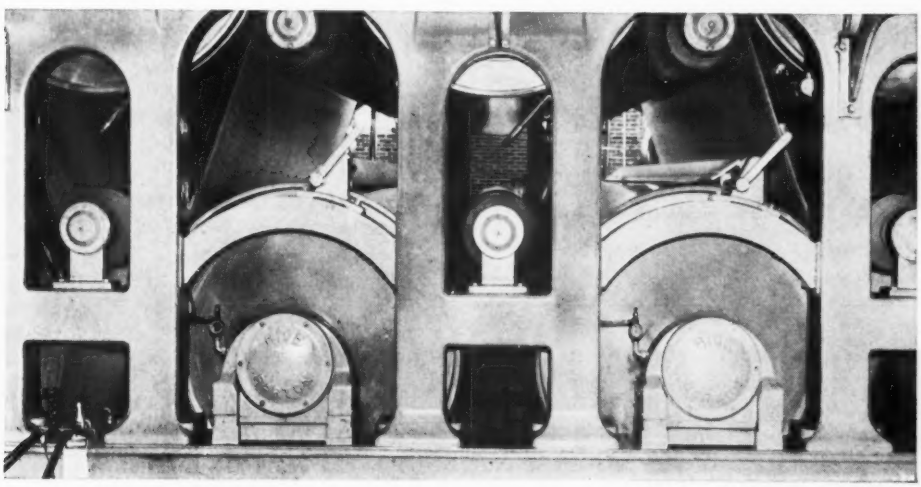
There are two modifications of the above dryer section which are worthy of mention at this time. The Yankee machine has one very large dryer, considerably over ten feet in diameter, instead of several smaller dryers. The capacity of this unit is limited by the drying capacity of the dryer. It produces an excellent shiny surface to one side of the paper which cannot be obtained by the typical calenders. Paper napkins, towels and tissues can be made on a Yankee machine.

The Minton Vacuum Dryer is the second modification. In this unit the entire dryer section including rolls and felt is enclosed in an airtight chamber. Seals on either end of the chamber permit the wet paper to enter and the dry paper to leave without breaking the vacuum maintained in the chamber. The use of vacuum permits drying at lower temperatures and the steam consumption is considerably lower. These benefits are offset by the higher initial costs.

Dry End Lubrication

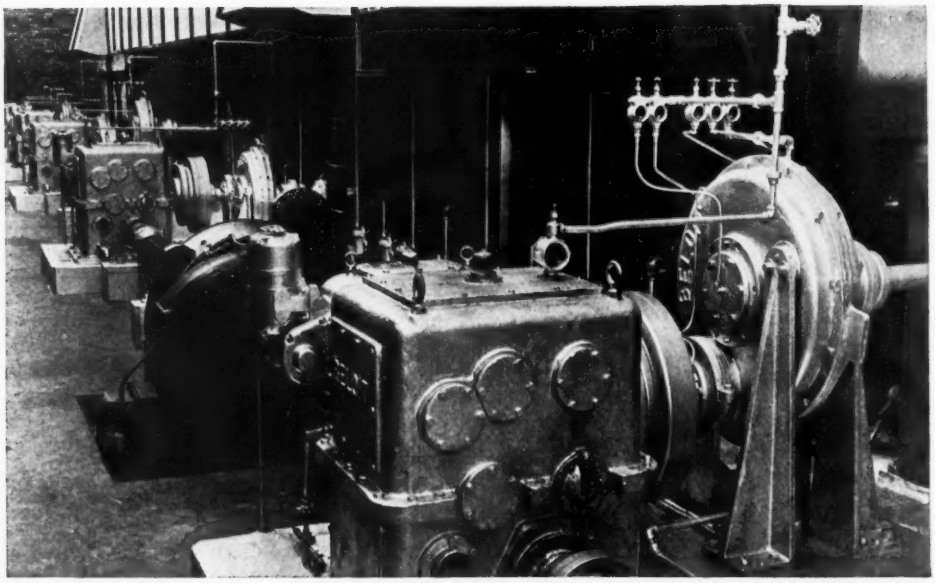
There are several paper machines in operation today in which the dryer sections have plain bearings lubricated with block greases or with oil applied to waste. Several others have hand or wick fed oil lubricated plain or anti-friction bearings. These are in the minority as far as paper tonnage is concerned and their lubrication will not be mentioned.

The lubrication of self-aligning double roller bearings, which are universally used on all new



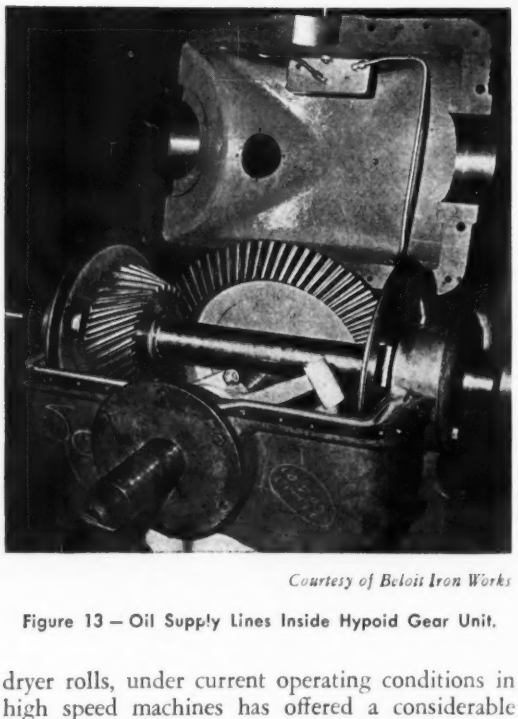
Courtesy of Rice Barton Corporation

Figure 11 — Tending Side of Dryer Section Showing Oil Feed Lines to Bearings.



Courtesy of Beloit Iron Works

Figure 12 — Differential Drive on Fourdrinier Machine.



Courtesy of Beloit Iron Works

Figure 13 — Oil Supply Lines Inside Hypoid Gear Unit.

dryer rolls, under current operating conditions in high speed machines has offered a considerable challenge. The demand for greater paper production with existing equipment necessitated resorting to higher steam pressures in the dryer sections in order to speed up the drying. The higher temperatures resulted in numerous bearing failures where cognizance was not taken of the more severe operating conditions and improved oils were not placed in service.

The factors which influence the lubrication of dryer section bearings and gears include:

(a) Type of bearings
(b) Bearing temperature
(c) Bearing pressure
(d) Oil contamination by moisture
(e) Method of Oil Application.

Bearings

The bearings used in the dryer section are heavy duty roller bearings. These bearings are very carefully designed, with the purpose of assuring maintenance of dependable lubrication. The use of antifriction bearings has reduced the lubrication and maintenance costs per ton of paper.

Temperature

The bearing and gear case temperatures in the dryer section are influenced by the steam which is used. Steam at a pressure of 125 P.S.I. which is frequently encountered in present operations has a temperature of 350°F. and bearing surface temperatures of over 275°F. seem logical. The effect of increased steam pressures on lubrication has been to require a more oxidation resistant oil and one with sufficient load carrying capacity at the higher temperatures to protect the bearings from failure.

Bearing Pressure

The comparatively high contact pressures which

must be maintained between the surfaces of the dryer rolls in order to develop the necessary squeezing and final drying of the web are of necessity imparted to the bearings which carry these rolls. These pressures are most effectively counteracted by flood lubrication in the bearing housing with a lubricant capable of protecting the bearings from damage due to these pressures. This requires prior consideration of load carrying capacity over heat transfer ability since the latter can be controlled by increasing the flow of lubricant to the bearings and the installation of oil coolers if necessary.

Contamination

The possibility of oil contamination in the circulating system on a dryer section is always present. Contamination is always with water which enters the oil either by condensation in the cooler parts of the circulating system or by leaks which frequently develop in the steam joints. Water contamination is a considerably more serious problem in today's high speed machines since they are lubricated with relatively water sensitive detergent type oils in comparison to the straight mineral oils previously used and from which the water readily separated. In order to insure trouble free operation precaution should be exercised to keep water out of today's circulating oil system.

Lubrication by Oil Circulation

The oil circulating system, as designed for the modern paper machine, has required careful engineering in designing the distribution and return piping, tankage for oil storage and filtration unit. The pumps must have adequate capacity to keep a full oil stream flowing through the bearings while the machine is in motion.

The dryer section of the paper machine offered one of the most promising points for improvement in lubrication by application of oil circulation. This became more apparent with the adoption of antifriction double roller bearings in this service since these were provided with oil seals. The adoption of automatic flood lubrication required the development of a filtration system which would result in a sufficient degree of oil cleanliness to insure good lubrication.

A number of methods of oil circulation have been used, ranging from the simple gravity feed to the multiple outlet devices whereby an entire series of roller bearings can be served simultaneously under constant pressure. The latter is usually preferred as the most dependable method of dryer bearing and gear lubrication where so many costly bearings are involved. The circulating oil not only insures lubrication but also removes considerable heat, which is very desirable.

Full Pressure Lubrication

In a full pressure system a supply pump delivers oil at a predetermined pressure from the settling tank to a pressure tank in which an air cushion is provided at the top. Usually two pumps are provided, one of which may serve as a spare. This latter cuts in automatically, by means of electrically operated pressure switches when the pressure in the pressure tank drops below a predetermined minimum, due to failure of the operating pump, or whenever the latter is unable to maintain the desired pressure. If both pumps fail or are unable to maintain sufficient pressure, a third pressure switch, which is set just below the minimum operating pressure required, sounds an alarm. A pressure regulated by-pass valve in the supply line to the machine allows any excess oil to return to the clean oil compartment of the filter tanks.

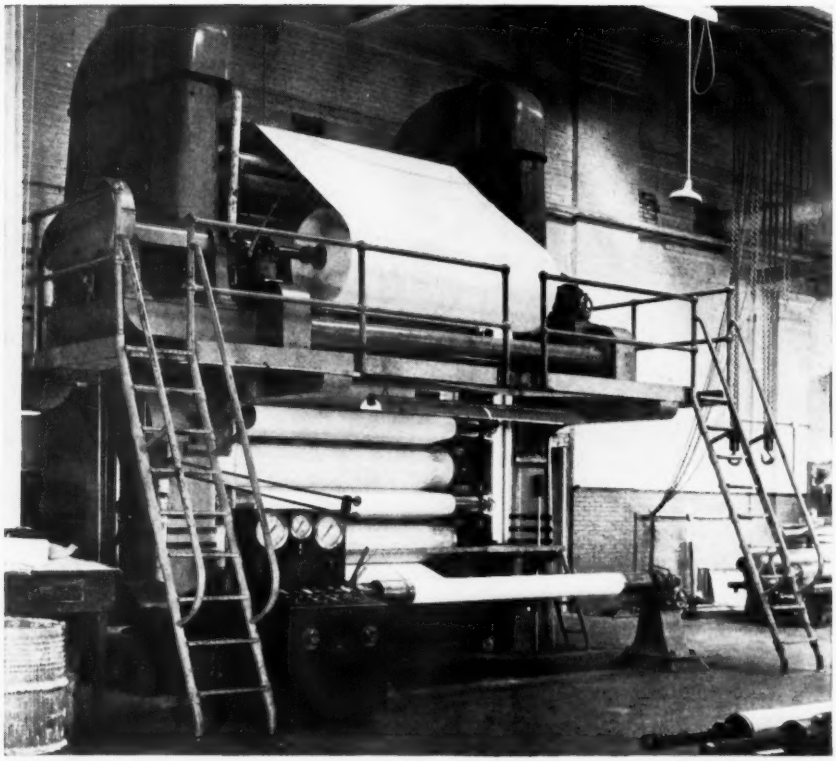
The expansive action of the air cushion in the pressure tank forces the oil through the main supply line and the numerous branch lines; these are equipped with orifice plates or valves, to provide each bearing or gear unit with its proper share of lubricant. Frequently each of the various points of lubrication is equipped with a pressure switch and light signal to warn the operator, should the oil flow be interrupted. The return oil from the gears or bearings flows back to the settling tank by gravity; here it is subjected to filtration and purification to fit it for recirculation.

Oil Reconditioning

Before being recirculated the oil is normally subjected to three stages of purification. In the settling tank, any water which may have been picked up by the oil has a chance to settle out and is removed through draw-off lines. Upon overflowing the settling tank the oil is subjected to gravity filtration through filter fabrics which retain any suspended solid material. In recent years an additional set of filters has been placed on the circulating oil pump discharge to remove any very fine material that may not have been previously removed.

With the introduction of detergent type oils into dryer circulating oil systems it has been found that the cotton-wool filter fabrics were subject to rapid deterioration. Experiments have shown that considerably longer filter life is obtained when synthetic fabrics such as dynel, dacron or orlon are used. Some of the larger circulating oil systems have as many as ninety filters and considerable savings are possible by using the synthetic filtering media.

Active clay type filters should not be used in



Courtesy of The Appleton Machine Company

Figure 14 — Super Calendar Stack.

this service since they selectively absorb the additives from the oil and lower their effectiveness.

Centrifugal Purifiers

Centrifuges have been used as auxiliary equipment to remove water from circulating oils for a number of years. They are usually operated intermittently to remove excessive amounts of water from the circulating oil.

The use of centrifuges in this service is being extended at the present time as circulating systems are being promoted in which purification is effected solely by the use of a centrifuge followed by filtration through inert filtering media.

Oil Coolers

It is frequently desirable in high speed machines to install oil coolers in the circulating oil system to reduce the oil temperature to a point where more effective cooling is obtained and at the same time lessen oil oxidation.

Lubricating Oil Characteristics

The straight mineral oils formerly used in dryer circulating oil systems left considerable to be desired since they did not insure against corrosion due to water and during extended runs left a carbonaceous deposit on the bearings which had to be manually removed which resulted in operating delays.

The oxidation resistant, detergent and dispersant oils recommended for our present high speed dryers correct all the deficiencies of the former products. These oils have the following advantages.

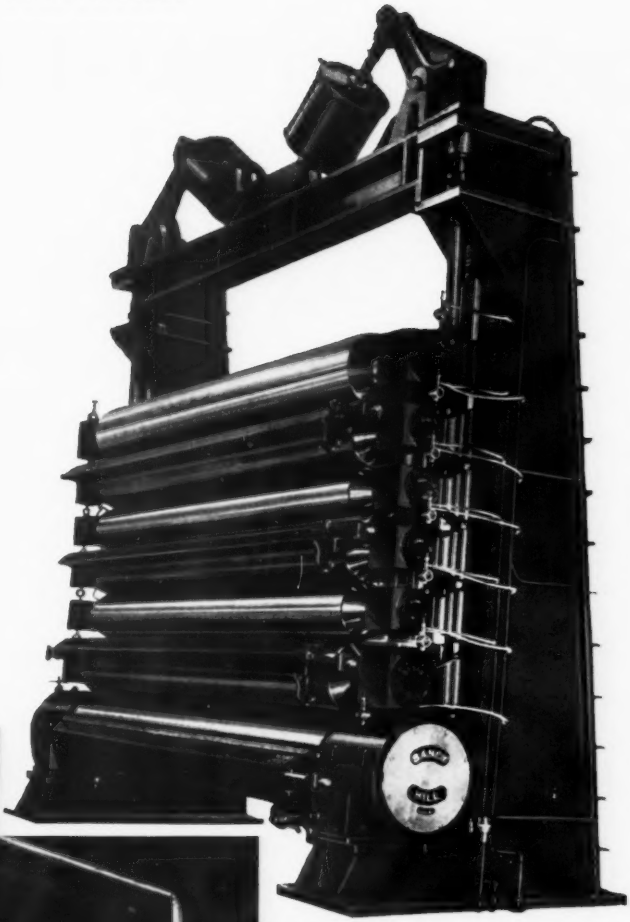
(1) They have been fortified to resist oxidation under the more severe operating conditions experienced today.

(2) Their detergent characteristics permit their keeping the bearings and gears free of oil oxidation products, water, paper dust and sludge. They remove these materials from the machine parts and carry them to the filtering tanks where they are removed from the system. By removing any water from the system, they prevent corrosion which would otherwise occur.

(3) They also possess dispersant properties which permit their holding extraneous material in a fine state of dispersion which prevents their settling out before they reach the filter.

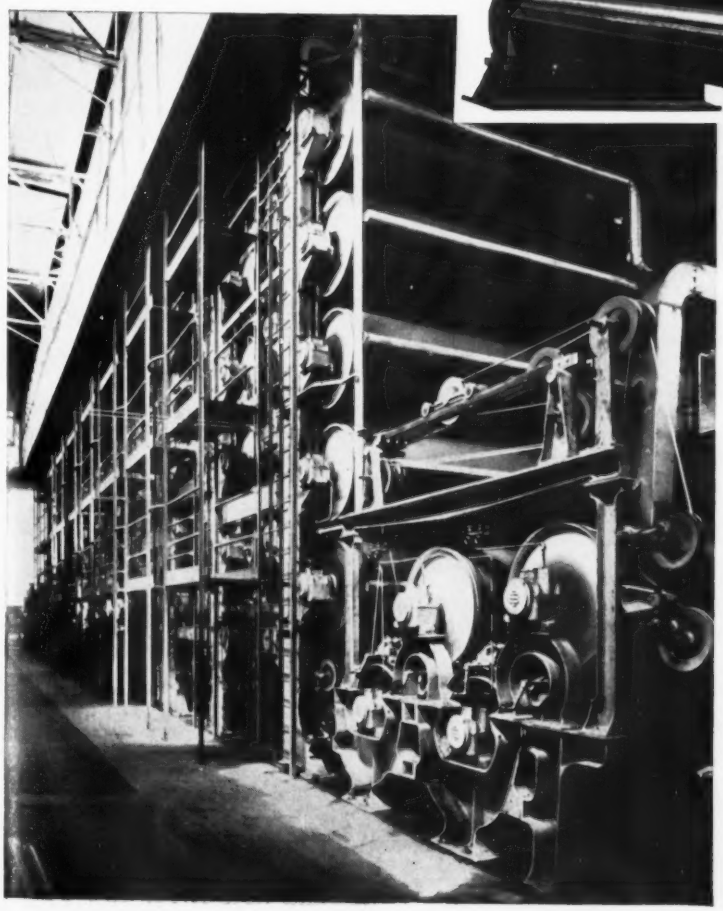
Courtesy of Bowser, Inc.

Figure 15 — Cartridge Filter for Secondary or "Polishing" Oil Filtration.



Courtesy of The Sandy Hill Iron & Brass Works

Figure 16 — End View of a Calendar Section Showing Oil Leads to Bearings.



Courtesy of Shartle Bros. Machine Co. Division of Black-Clawson Company

Figure 17 — Vertical Dryers on Pacific Coast Board Mill.

(4) The load carrying capacity of the new paper machine oils at the operating temperatures is much higher than that of any other type of oil used in this service. This is the most important characteristic of these oils as field experience has definitely shown that other oils do not provide adequate bearing protection at the higher operating temperatures. A large number of bearing failures have resulted from using oils of inadequate load carrying capacity at high temperatures on dryers using 100 P.S.I. steam. While these oils provided adequate protection at the lower drying temperatures they failed at the higher temperatures.

The effect of temperatures upon the load carrying capacity of oils is shown below:

Maximum Film Strength, P.S.I. (Steel on Steel)	Straight Mineral Oil	Anti Oxidant Dispersant and Detergent Oil
at 100°F.	59,000	78,500
at 200°F.	23,500	44,000
at 300°F.	13,000	43,000

The load carrying capacity of circulating oils is very significant since the bearings are very expensive and delays caused by having to replace bearings are very costly.

Drives

The dryer rolls are connected through a gear train consisting of spur or helical gears, or by means of roller chains, to synchronize their rotation and maintain the proper tension on the paper passing between them.

In most modern machines these gear trains and chains are enclosed in an oil-tight housing and are lubricated by a circulatory system which is similar to, or is the same system, which lubricates the bearings. Being on such a system assures that an adequate supply of clean protective lubricant is provided at all times. The same characteristics of the lubricant for the bearings are highly desirable for the lubrication of these gears and chains in order to assure minimum wear, protection against rusting and freedom from deposits.

Some machines, however, may be equipped with gears which are exposed; a lubricant having good adhesive qualities and capable of withstanding relatively high temperatures is required for this service. This type of lubricant may be applied by brushing or pouring onto the gears or by dripping on to the teeth either by gravity or a mechanical lubricator.

Herringbone, spiral bevel or hypoid gears, are used as main drives for operating the calenders. Generally they are lubricated by a self-contained system as they are subjected to severe tooth loading and rubbing. This combination, which is most serious in a hypoid drive, can easily cause gear failure if the right lubricant is not used.

The mild E.P. type non-corrosive gear lubricant is favored for hypoid gears. The extreme pressure characteristics are permanent; the ingredients do not separate in storage or service and this type of lubricant is adhesive to the gear teeth.

CONCLUSION

The role played by the lubrication engineer and oilers in our paper mills is more important today than it has ever been in the past. This is due to the advancements made in equipment throughout the mill, which in a number of cases resulted in one unit doing the work of two, and the increased rate of paper production. Correct lubrication is vital to protect the increased equipment costs and prevent the more costly production loss. The petroleum chemists are familiar with the changing conditions in the paper industry and have produced oils and greases which will continue to lubricate effectively the various units. It is essential however that they be used in accordance with recommended practice in order to insure optimum results.

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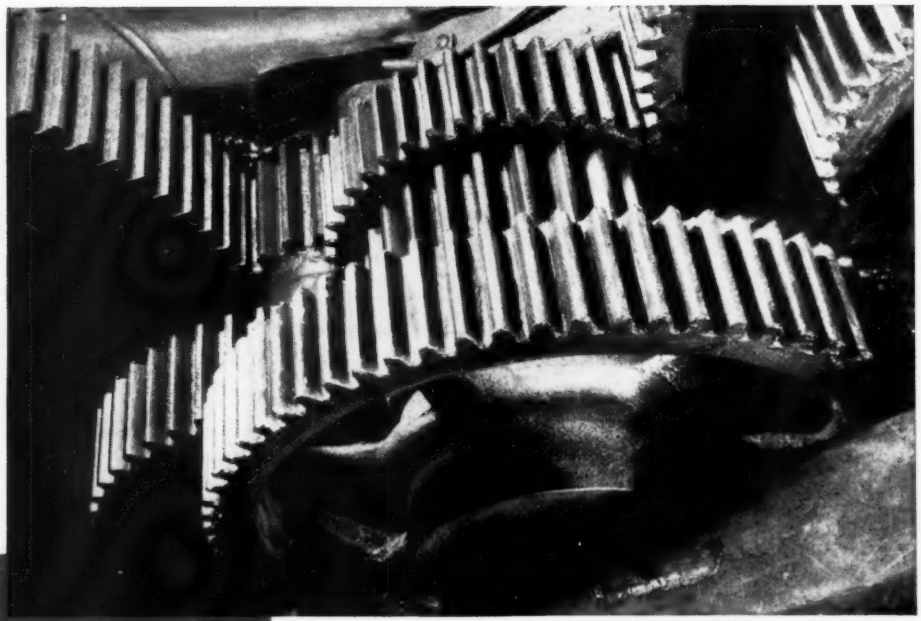

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